STEM II: Applications

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
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Course Code:	TBD
Prerequisite(s):	*STEM I: Foundation*; *Algebra I*; and *Physical Science* or *Biology*
Credit:	1
Grade Level:	10
Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other STEM courses.
Programs of Study and Sequence:	This is the second course in the *STEM Education* program of study.
Necessary Equipment:	Equipment list can be found on the STEM website.
Aligned Student Organization(s):	Skills USA: http://www.tnskillsusa.com Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/wb/.
Available Student Industry Certifications:	None
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	477, 013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 210, 211, 212, 213, 214, 413, 414, 415, 416, 417, 418, 230, 231, 232, 233, 470, 477, 519, 531, 595, 596
Required Teacher Certifications/Training:	Teachers who have never taught this course must attend training provided by the Department of Education.
Teacher Resources:	http://www.tn.gov/education/cte/doc/STEMResourceList.pdf

Course Description

STEM II: Applications is a project-based learning experience for students who wish to further explore the dynamic range of STEM fields introduced in *STEM I: Foundation*. Building on the content and critical thinking frameworks of *STEM I*, this course asks students to apply the scientific inquiry and engineering design processes to a course-long project selected by the instructor with the help of student input. Instructors design a project in one of two broad pathways (traditional sciences or engineering) that reflects the interest of the class as a whole; the students then apply the steps of the scientific inquiry or the engineering design process throughout the course to ask questions, test hypotheses, model solutions, and communicate results. In some cases, instructors may be able to design hybrid projects that employ elements of both the scientific inquiry and the engineering design process. Upon completion of this course, proficient students will have a thorough understanding of how scientists and engineers research problems and methodically apply STEM knowledge and skills; and they will be able to present and defend a scientific explanation and/or an engineering design solution to comprehensive STEM-related scenarios.

Note: Standards in this course are presented sequentially according to the traditional steps followed in the scientific inquiry or engineering design process. While instructors may tailor the order of course standards to their specifications, it is highly recommended that they maintain fidelity to the overall process. In addition, instructors opting for either the Science Path or the Engineering Path do not have to teach to both sets of standards; they are presented in parallel fashion here for ease of comparison, should teachers wish to combine elements of each.

Program of Study Application

This is the second course in the *STEM Education* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the STEM website at http://www.tn.gov/education/cte/ScienceTechnologyEngineeringMathematics.shtml.

Course Standards

The Roles of Scientists and Engineers

Science Path	Engineering Path
1) Determine the scientist's role in explaining why phenomena occur in the natural world, justified by historical and current science knowledge. Research a known scientist and present in an informative paper, oral presentation, or other format his/her contributions to scientific knowledge. Include an outline of how the scientific inquiry process was used in his/her work. (TN CCSS Reading 1, 2, 3, 8, 9; TN CCSS Writing 2)	1) Determine the engineer's role in developing solutions to design problems that are justified by scientific knowledge. Research a known engineer and present in an informative paper, oral presentation, or other format his/her designs and explain how they influenced technology in his/her field. Include an outline of how the design process was used in his/her work. (TN CCSS Reading 1, 2, 3, 8, 9; TN CCSS Writing 2)

Questioning and Defining Problems

Science Path	Engineering Path
2) Engage in scientific inquiry by brainstorming for questions to understand how a certain phenomenon in the natural world works, to understand why a phenomenon occurs, or to determine the validity of a theory. (TN CCSS Reading 4, 5, 9)	2) Ask clear, relevant questions that lead to defining a design problem. For example, questions should be testable and explore the requirements of a problem solution, but not define the methodology to solve the problem. (TN CCSS Reading 4, 5, 9)
3) Research various sources (e.g., articles, end-uses, textbooks) and identify one or more questions that will guide a scientific investigation. For example, questions should be relevant, testable, and based on current scientific knowledge. (TN CCSS Reading 1, 4, 5, 6, 9; TN CCSS Writing 1, 4)	3) Brainstorm for several problem solutions, then conduct research using various sources (e.g., articles, end-uses, textbooks) to generate more solution ideas. Justify ideas using evidence from the sources. (TN CCSS Reading 1, 4, 5, 6, 9; TN CCSS Writing 1, 4)
4) Develop an original proposal as would a natural or social scientist that will guide the scientific inquiry and follow responsible ethical practices. For example, the proposal should outline the reason for the research interest, hypothesis, methodology, data analysis, importance of study, and deliverables. (TN CCSS Reading 3, 4, 7, 9; TN CCSS Writing 1, 7)	4) Develop a design brief that will guide a design process and follow responsible ethical practices. For example, the design brief should outline a problem definition, design statement, criteria, constraints, and deliverables. (TN CCSS Reading 3, 4, 7, 9; TN CCSS Writing 1, 7)

Modeling

Science Path	Engineering Path
5) Create models to illustrate questions and represent processes or systems that are justified by scientific evidence. For example, models can be diagrams, drawings, or scaled down physical representations. (TN CCSS Reading 1, 4, 7; TN CCSS Writing 4, 8, 9)	5) Create models to illustrate design criteria and represent processes, mechanisms, or systems. For example, models can be drawings, mathematical representations, or computer simulations. (TN CCSS Reading 1, 4, 7; TN CCSS Writing 4, 8, 9)
6) Use mathematics and technology to develop multiple models to predict an occurrence in the natural world. Compare and contrast the recorded observations from each model. For example, computer modeling can be used to analyze current	6) Identify and sketch at least three alternative solutions, to a problem, that consider analyses such as mechanical and electrical systems. For example, computer modeling can be used to analyze the effect of stress and strain on a beam. (TN CCSS

atmospheric conditions to predict the weather in days ahead. (TN CCSS Reading 7, 9; TN CCSS Writing 7, 9)	Reading 7, 9; TN CCSS Writing 7, 9)
7) Analyze results from modeling and appropriately determine when it is necessary to revise questions. Justify revisions with evidence. (TN CCSS Reading 7, 9; TN CCSS Writing 9)	7) Conduct iterations of modeling a solution to a design problem, demonstrate that design criteria are met, and select a reliable design approach. (TN CCSS Reading 7, 9; TN CCSS Writing 9)

Planning & Investigating

Science Path	Engineering Path
8) Make a hypothesis that explains a scientific question, plan and conduct a simple investigation, and record observations (e.g., data) in a manner easily retrievable by others. (TN CCSS Reading 3; TN CCSS Writing 4)	8) Develop a design proposal to create prototypes for testing. The proposal should provide details such as drawings with dimensions, materials, and construction process. (TN CCSS Reading 3; TN CCSS Writing 4)
9) Identify the independent variables and dependent variables in an investigation. Demonstrate the effects of a changing independent variable on a dependent variable, and observe and record results. (TN CCSS Reading 3; TN CCSS Writing 7, 9)	9) Outline testing procedures that identify type of data (e.g., number of trials, cost, risk, and time) that is needed to produce reliable measurements and the specifications (e.g., effectiveness, efficiency, and durability) to determine whether a design has exceeded or failed expectations. (TN CCSS Reading 3; TN CCSS Writing 7, 9)

Data Analysis & Interpretation

Science Path	Engineering Path
10) Use mathematics to represent and solve scientific questions. For example, simple limit cases can be used to determine if a model is realistic. (TN CCSS Reading 3, 7)	10) Use mathematics to represent and solve engineering problems. For example, simple limit cases can be used to determine if a model is realistic. (TN CCSS Reading 3, 7)
11) Evaluate data and identify any limitations of data analysis. Using this information, determine whether to make scientific claims from data or revise an investigation and collect more data. (TN CCSS Reading 3, 7; TN CCSS Writing 7)	11) Evaluate data and identify any limitations of data analysis. Using this information, determine whether a design solution is optimal or should be refined and tested again. (TN CCSS Reading 3, 7; TN CCSS Writing 7)

12) Compare and contrast the data results from multiple iterations of a scientific investigation. For example, consider how well each explanation is supported by evidence, prior research, and scientific knowledge. (TN CCSS Reading 3, 7, 9; TN CCSS Writing 1)	12) Compare and contrast the data results from testing multiple design solutions. For example, consider how well each design solution meets the design criteria and constraints. (TN CCSS Reading 3, 7, 9; TN CCSS Writing 1)

Problem Solutions & Scientific Explanations

Science Path	Engineering Path
13) Develop an explanation to a scientific question that is logically consistent, peer reviewed, and justified by data analysis and scientific knowledge. (TN CCSS Reading 4, 7, 9; TN CCSS Writing 1, 5, 7, 8, 9)	13) Develop an optimal design solution that is justified by data analysis and scientific knowledge, and meets ethical and design criteria and constraints. (TN CCSS Reading 4, 7, 9; TN CCSS Writing 1, 7, 8, 9)

Communicating Solutions & Explanations

Science Path	Engineering Path
14) Develop a technical report to communicate and defend a scientific explanation and justify its merit and validity with scientific information. Consider the ethical implications of the findings. The report can include tables, diagrams, graphs, procedures, and methodology. For example, conduct a STEM forum, present scientific research, and provide evidence to support arguments for or against scientific solutions. (TN CCSS Reading 4, 7, 9; TN CCSS Writing 1, 5, 6, 7, 8, 9)	14) Develop a design document to communicate the final design solution and how well it meets the design criteria and constraints. For example, the design document can include charts, graphs, calculations, engineering drawings, as well as information regarding marketing, distribution, and sales. For example, conduct a STEM forum, present engineering design briefs, and provide evidence to support arguments for or against design solutions. (TN CCSS Reading 4, 7, 9; TN CCSS Writing 1, 5, 6, 7, 8, 9)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
    - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.

- TN CCSS Writing: Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
    - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3, 6, and 10 at the conclusion of the course.
- TN CCSS Math: Common Core State Standards for Mathematics; Math Standards for High School: Numbers and Quantity, Algebra, Functions, Geometry, Statistics and Probability.
    - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project-based activities or collaborate on lesson planning. Students who are engaging in activities listed above should be able to demonstrate quantitative, algebraic, functional, geometric, and statistical reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.